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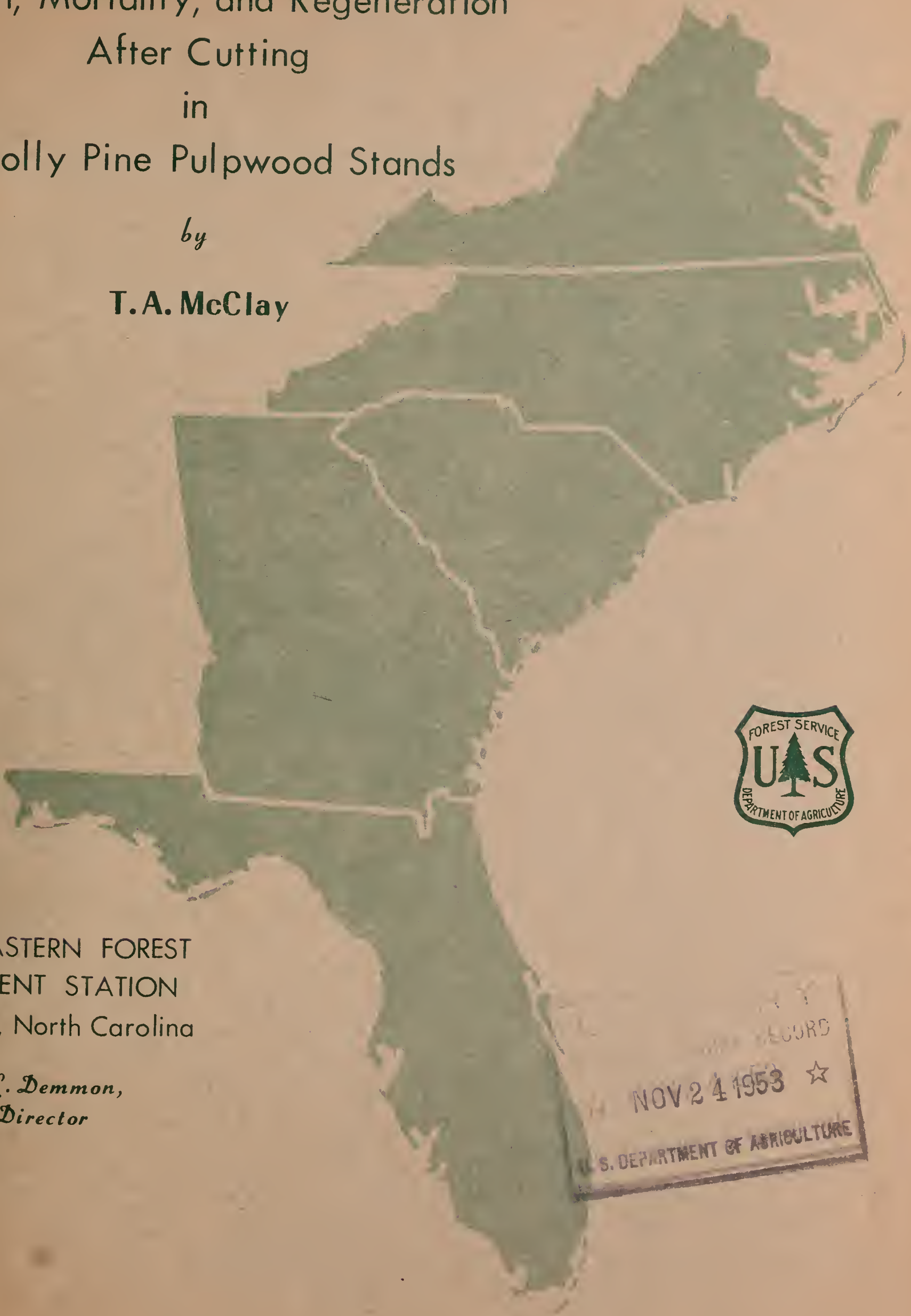
Growth, Mortality, and Regeneration After Cutting in Loblolly Pine Pulpwood Stands

by

T. A. McClay



SOUTHEASTERN FOREST
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E. L. Demmon,
Director

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GROWTH, MORTALITY, AND REGENERATION

AFTER CUTTING IN LOBLOLLY PINE PULPWOOD STANDS

by

T. A. McClay
Santee Research Center, Charleston, S. C.

INTRODUCTION

The age at which even-aged stands of loblolly pine start to show a decrease in cordwood growth rate depends primarily on site and density of stocking. For the majority of pine pulpwood stands in the mid-Atlantic coastal region, MacKinney and Chaiken (4) show that culmination of mean annual increment occurs between 30 and 40 years of age. It will occur earliest in high-density stands on good sites. In a study comparing the growth between thinned and unthinned loblolly pine stands in central Louisiana, Mann (5) reports that the greatest periodic annual cordwood growth occurred in unthinned stands up to age 33 on an average site index 93. After that age, heavy mortality in the merchantable size classes reduced the growth below that of the thinned stands. Although considerations such as product objective, early thinnings at a net profit, or logging cost as affected by tree size may influence the decision, it appears that when a stand approaches about 30 years of age, it would be advisable to make plans for some type of cutting to salvage expected mortality and to stimulate the growth rate.

METHODS OF CUTTING

In 1939, five blocks of six 0.4-acre plots each were located throughout the range of loblolly pine in Virginia and the Carolinas. The objective was to test the effects of six different methods of cutting in even-aged stands of pine pulpwood when (1) cutting pulpwood as a short-rotation final crop and, (2) cutting pulpwood as an intermediate crop in a long rotation aimed at the ultimate production of sawtimber, poles, and piling.

The short-rotation cutting methods were:

1. Seed-tree cutting removing all trees 5.0 inches d.b.h. and larger except four seed trees 9.0 inches d.b.h. and larger per acre. At the time of study establishment, the minimum diameter of a seed tree was considered to be 10.0 inches d.b.h. in Virginia and North Carolina, and 8.0 inches d.b.h. in South Carolina.

2. Seed-tree cutting removing all trees 5.0 inches d.b.h. and larger except 12 seed trees 9.0 inches d.b.h. or larger per acre.

3. Two cut shelterwood (6) removing all trees 5.0 inches d.b.h. and larger except 40 trees per acre of the best dominants and codominants after the first cut.

The long-rotation cutting methods were:

4. Diameter-limit cut removing all trees 7.0 inches d.b.h. and larger.

5. Moderate thinning from below leaving about 160 of the best trees per acre.

6. Heavy thinning from below leaving about 100 of the best trees per acre.

The averages for each treatment showed a volume before cutting of 25 to 35 cords per acre, an age of 25 to 30 years and a site index (average height of dominant and codominant trees at 50 years) of 75 to 85 feet. Two plots were well out of this range and were not included in the analysis. The last remeasurement of all plots was made in the winter of 1947-48, or 9 years after the initial cut. There were no stand improvement measures applied during this period.

Good forest management policy today would not accept the rather crude short-rotation cutting methods as practiced in this early study. New methods of seed-tree selection and stimulation, seedbed preparation, and control of inferior understory species are some of the techniques considered advisable to secure satisfactory regeneration. However, there are large acreages of loblolly pine stands not under intensive management which are still being cut by some of the methods practiced in this study. The records of growth, mortality, and regeneration during the 9-year period following cutting by the six methods tested provide some useful information regarding these stands.

GROWTH AND MORTALITY

A treatment comparison of average growth of the residual merchantable stand, ingrowth of new trees, and mortality during the 9-year period following cutting is shown in table 1. Representative conditions on diameter-limit

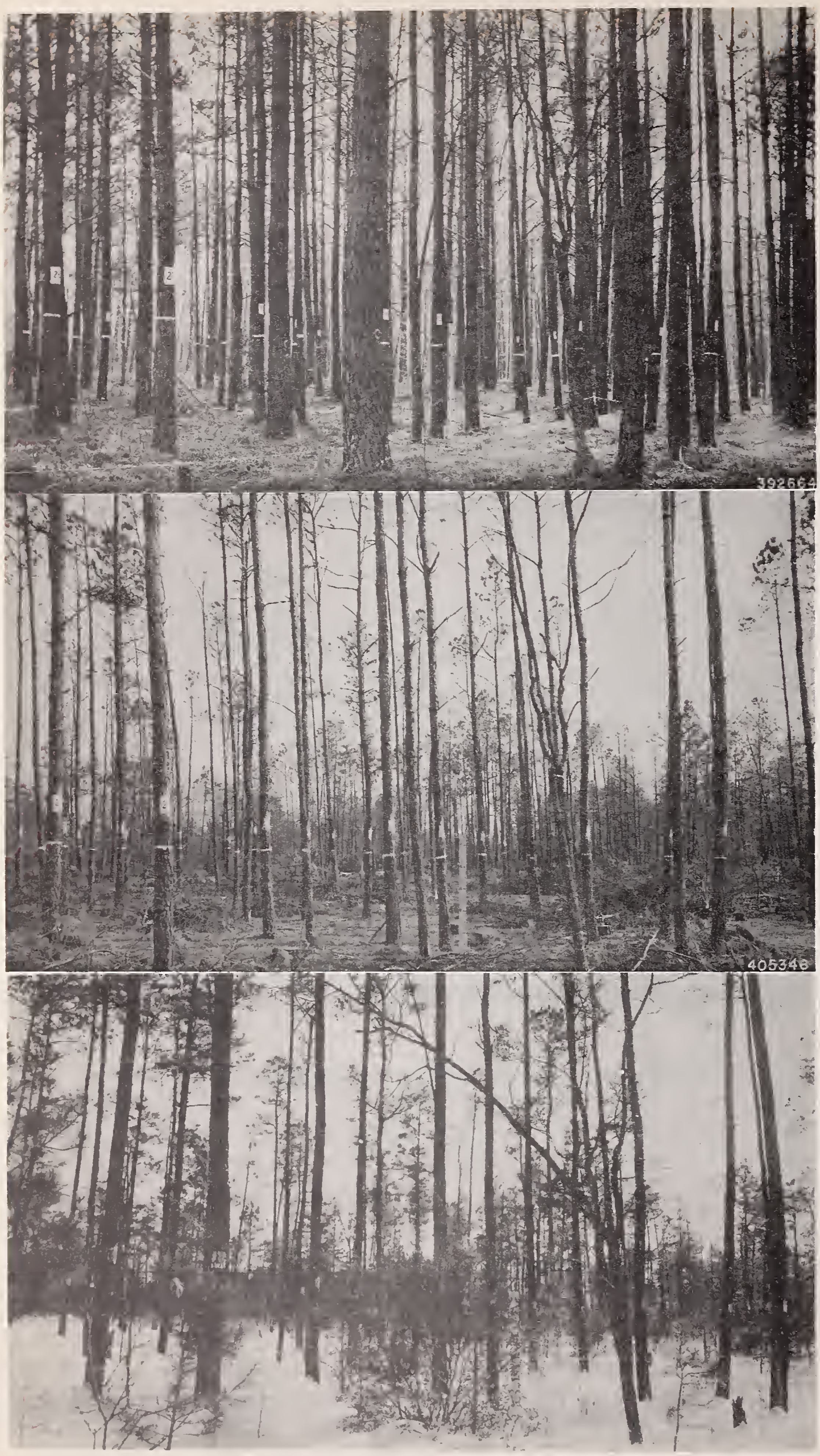
Table 1.--Growth and mortality per-acre, following different methods of cutting

Method of cutting	Volume			Periodic annual--			Compounded growth rate	
	Cut	Left	9 Years later	Residual net growth	Ingrowth	Mortality	Residual stand	Residual plus ingrowth
	Cords	Cords	Cords	Cords	Cords	Cords	Percent	Percent
4 seed trees	27.6	1.3	3.5	.09	.15	0	5.5	11.5
12 seed trees	26.1	2.3	5.6	.20	.18	.01	6.6	10.7
Shelter-wood	23.3	6.8	13.2	.62	.10	.01	6.9	7.7
Diameter limit	22.7	6.1	8.0	.24	.09	.12	3.4	4.5
Moderate thinning	10.0	13.9	22.1	.86	.11	.06	5.0	5.6
Heavy thinning	15.0	12.7	21.3	.88	.11	.03	5.5	6.1

and heavy-thinning plots before and after cutting and 9 years later are shown in figures 1 and 2.

Volume growth in cords of the residual stand was greatest following the thinning treatments, where it averaged almost 0.9 cords per acre per year. The shelterwood produced a growth of about 0.6 cords, while the seed-tree and diameter-limit cuts had only 0.1 or 0.2 cords annual growth increase. These growth rates bear a strong relationship to the residual volumes left per acre in all cases except the diameter-limit cut. Under this treatment, the merchantable volume left was in the 5- and 6-inch diameter classes, consisting mainly of trees which were suppressed in the original stand; all the other cutting methods left a residual stand composed mainly of former dominants and codominants.

All cutting methods left small-crowned, low-vigor trees below 5.0 inches d.b.h. The ingrowth from this group into merchantable size was influenced greatly by degree of release. The seed-tree cuts, which gave the most release, resulted in an ingrowth some 50 to 75 percent greater than under the other cutting methods. Although the diameter-limit cut removed all competition by the larger trees, 195 trees per acre were left in the 5- and 6-inch diameter classes to compete directly with trees smaller than 5.0 inches.



BEFORE

AFTER

NINE YEARS

Figure 1.--This 25-year-old pine stand near Jarratt, Va., was cut to a 7.0-inch minimum diameter limit. Trees with number and band represent the 5- and 6-inch d.b.h. residual stand. All other merchantable trees were cut. This method of cutting appears least favorable.

CUTTING

CUTTING

AFTER CUTTING

Figure 2.--A 27-year-old pine stand given a heavy thinning where all merchantable trees except 100 of the best dominants and codominants per acre were cut. Trees with number and band represent residual stand. This method of cutting produced the best volume growth and gross returns. Plot located near Jarratt, Va.

Mortality was almost nonexistent following the seed-tree and shelterwood cuttings, where there were no suppressed residuals of merchantable size with small crowns left. An increase in the number of poor-vigor trees left brought about a corresponding increase in mortality. The moderate thinning left more of these trees than the heavy thinning, and the mortality rate was doubled. The residual stand left after the diameter-limit cut was composed almost entirely of trees which had been suppressed in the original stand, and here the mortality rate was greatest. It amounted to a loss of 0.12 cords per acre per year, or about 18 percent of the merchantable volume left after cutting. Chaiken (3) has reported a similar high mortality among poor-vigor trees left after partially cutting a stand of loblolly pine sawtimber. He states it would be well to anticipate this mortality and to remove such trees, in addition to those with severe logging injuries, at the time of cutting. It would appear that consideration should also be given to removing this class of tree in pulpwood stands, if it can be done economically.

When growth is considered as a compounded interest rate, the residual volume left by the shelterwood cut shows the highest growth rate with 6.9 percent. The 12-seed-tree cut produced 6.6 percent; the heavy thinning and four-seed-tree cut each had 5.5 percent; the moderate thinning had 5.0 percent; and the diameter-limit cut had a growth percent of only 3.4 percent. The high ingrowth relative to residual stand net growth, jumped the growth percent of the seed-tree cuts to about 11 percent, but the rates by the other cutting methods increased only slightly. Mortality is not included in the growth percents since it would be uneconomical to attempt to harvest these small volumes.

Leaving a low residual volume just to get a higher growth percent is not necessarily the best choice. To take an extreme example, leaving 2 cords per acre by a seed-tree method would produce about 1/3 cord per acre per year. In order to get the same annual volume of wood as that produced by the thinning methods (1.0 cord) would necessitate holding three times the acreage. The investment in wood volume by the seed-tree method (6 cords) would be about half that by the thinning methods (13 cords), but the investment in land and taxes would be three times as much while at the same time other costs such as road building and maintenance, fire protection, cruising, etc. would also be increased. Clearly then, a relatively high growth percent is not a final criterion by which to judge the desirability of a particular method of cutting.

FINANCIAL COMPARISONS

The techniques of comparative valuation provide a better measure of the relative financial returns associated with each method of cutting. This is simply computing the present worth (1939) of a given stand by adding the discounted value of the stand 9 years after applying a particular method of cutting to the value of the volume removed at time of cutting. Constant stumpage prices and discount rates are applied in the analysis to all methods of cutting. Since they apply equally to the volumes produced by any method,

and since we are seeking only to make a comparative rather than actual valuation, any price or rate will suffice. Those used here are \$4.00 per standard rough cord, \$30.00 per thousand board feet (Int. 1/4-inch rule), and a discount rate of 3 percent.

Thus, we assume an even-aged stand of pulpwood-size pine containing 25 cords per acre. Which of the six methods of cutting will produce the highest present worth? The present worth of this 25-cord stand before cutting is \$100 per acre (25 x \$4.00 per cord). The percent of total volume cut by each method can be computed from table 1. It ranges from 96 percent when leaving four seed trees to 42 percent when making a moderate thinning. The volume removed in each method of cutting is valued as pulpwood at \$4 per cord. The future stand may in some cases, however, have grown to a point where there is an operable amount of sawtimber volume in trees 10.0 inches d.b.h. and larger. Nine years after cutting, then, the stand may have sawtimber values in combination with pulpwood values. Or, if utilization policy requires it, the entire stand of trees regardless of size may be valued as pulpwood only.

The present worth resulting from each method of cutting when (1) all volumes are considered as pulpwood, and (2) the stand 9 years hence is valued as sawtimber and pulpwood combined, is shown in table 2.

The differences in present worth between treatments are not very large when all volumes are cut and valued as pulpwood. The greatest present worth (\$117 per acre) results from the heavy thinning; the shelterwood cut and moderate thinning are slightly less with \$114 and \$113, respectively. There is a further decrease when cutting to 12 or 4 seed trees, where the respective present worth is \$109 and \$106. Diameter-limit cutting is lowest with \$104 per acre.

Even though the values of the original cuts leaving seed trees were almost double the values removed in the thinning operations, the growth of the residual stands left after thinning more than made up this initial difference. The annual growth in cords for the diameter-limit method was almost equal to that for the 12-seed-tree method, but the present worth was reduced by the lower value of the initial cut. Other considerations such as a discount rate other than 3 percent, market trends, logging costs as affected by tree size, regeneration problems, or a combination of these factors, may easily alter the differences when all trees are cut and valued as pulpwood.

In 1948 all stands except those cut to a minimum 7.0 inches d.b.h. had an operable volume for a sawtimber cut, the lowest volume being some 1,000 board feet per acre on the areas cut to four seed trees. When the future stands are valued as sawtimber for trees 10 inches d.b.h. and larger and as pulpwood for trees 5- to 9-inches d.b.h., a pronounced difference appears in present worth by the various cutting methods. The shelterwood and thinning methods now show a definite superiority over the seed-tree or diameter-limit cutting methods. The heavy thinning produces a present worth of \$231 per acre, while the four-seed-tree and 12-seed-tree methods show a value of \$121 and \$138 per acre, respectively. The moderate thinning and shelterwood are \$192 and \$199, respectively, while the diameter-limit method has a present worth of only \$104 per acre. The latter method

Table 2.--Comparative value and present worth per acre after cutting by different methods

Method of cutting	Stand 9 years after cutting				Value of 1939 cut	Present worth (1939)	
	Valued[1] as--		Discounted[2] as--				
	Pulpwood	Sawtimber and pulpwood	Pulpwood	Sawtimber and pulpwood		Pulpwood	Sawtimber and pulpwood
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
4 seed trees	13	33	10	25	96	106	121
12 seed trees	22	60	17	46	92	109	138
Shelter-wood	48	159	37	122	77	114	199
Diameter limit	33	33	25	25	79	104	104
Moderate thinning	93	196	71	150	42	113	192
Heavy thinning	82	231	63	177	54	117	231

1/ Pulpwood stumpage $4.00 per standard rough cord. Sawtimber stumpage $30.00 per thousand board feet (Int. 1/4-inch rule). All figures rounded off to the nearest dollar.

2/ Discount rate 3 percent.

was low because it produced no trees of sawtimber size in the 9 years following cutting. The shelterwood and thinning methods had high present worth because the residual stand was composed primarily of select dominant and codominant trees. The seed-tree cuttings did not provide enough trees to produce an appreciable amount of sawtimber volume growth. A discount rate as high as 9 percent does not change the relative position of the present worths, although it does lessen the range of differences.

Table 2 also shows that when the stand is given a shelterwood cut, moderate thinning, or heavy thinning, a gross return of $236, $238, and $285 per acre, respectively, is earned in 34 to 39 years. This may be compared to clear cutting 25 cords per acre on a short rotation of about 25 to 30 years for a gross return of $100 per acre at $4.00 per cord. The rotation period will vary by site and density of stocking. Thus, by making a partial cut and carrying a thrifty residual stand to sawtimber size, it appears possible for one who sells stumpage at the quoted prices to realize in 34 to 39 years a gross return greater than that produced by two short-rotation clear cuttings in a period of about 50 to 60 years.

Financial comparisons between cutting methods based on data for a complete rotation would be highly desirable. The results obtained here are taken from records over a 9-year period following the initial cut and may not necessarily remain the same over a longer period. The possibility of later ingrowth into pulpwood or sawtimber classes, or the effect of additional cuttings in the thinned stands may tend to alter the value differences between cutting methods. It is difficult to find all the answers in a single study, but fitting together the results of many studies may offer a solution.

REGENERATION

Recent research findings have assisted owners in getting prompt and adequate loblolly pine regeneration.

Pomeroy (7) discusses the selection of good seed trees and the frequency of seed production, season of dispersal, and distribution. He suggests that seed trees should have large, dominant crowns with a past record of fruitfulness as indicated by the presence of many old cones. Trees 11 inches d.b.h. or smaller cannot be depended on as good seed trees. Occurrence of good seed years, season of logging, control of understory competition, and seedbed preparation are also important factors in aiding regeneration.

Trousdell (8) points out that logging slash provides a very poor seedbed, requiring 83 seeds per established seedling as compared to 29 seeds on undisturbed surfaces, 12 seeds on a logged and burned surface, and only 7 seeds on a disked and logged surface. Logging a stand leaves a seedbed pattern composed of slash, exposed mineral soil, and undisturbed areas. When logging is done with light equipment and heavy slash is left on the ground, it is apparent that a very large amount of seed would be needed to establish a new stand.

Even with an adequate seedfall on a suitable seedbed, the survival and growth of established pine seedlings can be seriously retarded by a dense understory of hardwoods. Chaiken (1, 2) discusses this problem and offers several means by which it may be overcome.

But none of these management techniques was being practiced in 1939. Seed trees were selected according to the standards of the time and although some of the seed trees were larger than 11 inches d.b.h. and showed evidence of being good seed producers, many of them were below this diameter and had no cones. This was particularly true in the shelterwood cutting, and to some extent in the 12-seed-tree cutting, where it was difficult to find a full quota of trees of proven seed-producing capacity. Truck roads were held to a minimum on the plots, slash was left undisturbed, and no measures were taken to improve seedbed conditions (figures 3 and 4). Three years after cutting there was an average of some 2,000 hardwood stems per acre on the seed-tree, shelterwood, and diameter-limit areas (table 3). By 1948 this had increased to from 3400 to 4900 stems per acre. No steps were taken to reduce this competition.

Table 3.--Number of hardwood stems per acre

Method of cutting	Size class	Stems per acre			
		1939	1942	1945	1948
		Number	Number	Number	Number
4 seed trees	under 4.5 ft.1/	--	1300	2215	3040
	over 4.5 ft.2/	420	755	842	1132
12 seed trees	under 4.5 ft.	--	1080	1340	3915
	over 4.5 ft.	342	607	777	978
Shelterwood	under 4.5 ft.	--	1095	1185	2245
	over 4.5 ft.	510	855	1010	1137
Diameter limit	under 4.5 ft.	--	1750	2355	2265
	over 4.5 ft.	387	818	907	1260

1/ Based on a 10-percent sample.
2/ Based on a 100-percent sample.

Under the circumstances, it is not surprising that a satisfactory new stand has failed to develop. Following cutting, all pine seedlings under 4.5 feet in height were eradicated on one-half the area of each plot cut by seed-tree, shelterwood and diameter-limit methods, regeneration not being an immediate problem on the thinned plots. The purpose was to obtain an estimate of seedlings produced exclusive of advanced reproduction. A 10-percent sample was made of all pine seedlings under 4.5 feet on both the eradicated and non-eradicated portions of the plots in 1942,

Figure 3.--One year after cutting a 27-year-old pine stand to 12 seed trees per acre (numbered trees). Hardwoods are infrequent and seedbed is still satisfactory, but seed trees averaged about 10 inches d.b.h. and none of them had old cones as evidence of seed-producing ability. By 1948 an adequate stand of reproduction had still failed to develop. Preharvest release of cone-bearing seed trees would have greatly increased the likelihood of success on this area.

Figure 4.--A 25-year-old pine stand one year after cutting to 12 seed trees per acre (some barely distinguishable in background) showing immediate problem created by understory hardwoods. Most of the seed trees on this plot bore cones at time of cut and by 1948 there were some 1500 pine stems per acre in the 0.6- to 4.5-foot height class. All of them, however, are overtopped by hardwoods. Elimination of competing species is essential for establishment of a succeeding pine stand.

1945 and 1948. An estimate of the number of established seedlings per acre, excluding those under 6 inches in height, by year and cutting method for the eradicated portions of the plots is shown in table 4.

Table 4.--Estimated pine reproduction under 4.5 feet in height[1]

Method of cutting	Total seedlings per acre[2]				Free seedlings per acre[3]
	1939	1942	1945	1948	1948
	Number	Number	Number	Number	Number
4 seed trees	0	260	980	1980	740
12 seed trees	0	360	760	2340	680
Shelterwood	0	250	1000	2370	370
Diameter limit	0	140	430	620	210

1/ Excluding reproduction under 6 inches in height.
2/ Based on 10-percent sample.
3/ Free of direct overhead shade.

Since the estimate is based upon a 10-percent sample not too much reliance can be placed on the actual figures, but even with a large error of estimate, it is evident that none of the cutting methods has produced an adequate crop of free-growing seedlings within a reasonable time. Side seeding from adjacent uncut stands has undoubtedly swelled the seedling count on many of the plots as evidenced by the seedlings on the areas cut to a 7.0-inch diameter limit. Some of the seedlings on the diameter-limit plots may have come from residuals which had developed an early seed-producing ability, although there are no data available to support this notion. An estimate of seedlings per acre on the non-eradicated portion of the plots shows that these portions had no more seedlings by 1948 than the eradicated portions, even though they had some at the start.

An interesting point is the steady increase in number of seedlings per acre over the 9-year period, in spite of the increasing hardwood competition as shown in table 3. More seed is being put down as the pine overstory trees become more mature, bumper seed crops occur, and some of the older seedlings manage to hang on or to find their way up through an opening. If one could accept a 6- to 9-year waiting period, stem-wise release of the established pine reproduction might provide the beginning of a new stand.

Of course, there are many pine pulpwood stands with relatively few hardwoods in the understory. Such stands cut by a seed-tree or shelterwood method may eventually develop a stand of pine reproduction without assistance. Although an unmanaged forest may thus produce a succeeding pine crop, it would be a risky venture involving an unnecessary time lag on lands acquired for the growing of timber.

A 100-percent tally of all pine over 4.5 feet high made after cutting and again in 1942, 1945 and 1948, further reveals the inadequacy of early stand development following cutting by seed-tree, shelterwood, or diameter-limit methods. The number of pine trees per acre by diameter group, year and cutting method is shown in table 5.

Table 5.--Pines per acre over 4.5 feet high, by method of cutting, diameter group, and year

Method of cutting	D.b.h. group	Total trees per acre 1/				Free-growing trees per acre 2/ 1948
		After cut, 1939	1942	1945	1948	
	Inches	Number	Number	Number	Number	Number
4 seed trees	0-1.9	10	8	188	380	239
	2.0-4.9	120	75	50	70	52
	5.0-9.9	0	15	32	38	35
	10.0 +	5	5	5	5	5
12 seed trees	0-1.9	30	25	172	365	197
	2.0-4.9	115	65	40	75	59
	5.0-9.9	1	15	35	48	45
	10.0 +	11	12	12	10	10
Shelterwood	0-1.9	48	28	72	192	90
	2.0-4.9	105	70	55	58	31
	5.0-9.9	22	22	28	30	23
	10.0 +	22	32	40	45	45
Diameter limit	0-1.9	55	40	52	60	28
	2.0-4.9	168	110	72	80	38
	5.0-9.9	195	190	195	185	172
	10.0 +	0	0	0	0	--

1/ Based on a 100-percent sample.
2/ Free of direct overhead shade.

If adequate reproduction had become established following cutting, and normal growth ensued, one might look for a substantial number of trees in the 0- to 1.9-inch diameter group by 1948. Yet this diameter group shows a deficiency for each cutting method. All residual stands had a decrease in the number of trees between 4.5 feet in height and 5.0 inches d.b.h. following cutting. It was not until 1945 (6 years after cutting) that the seed-tree stands made up this loss. In 1948 (9 years after cutting) the shelterwood stands made it up. And the stands cut to a 7.0-inch diameter limit still had fewer trees under 5.0 inches d.b.h. in 1948 than in 1939. The net

loss can be attributed to mortality due to logging damage and poor vigor, and to growth into larger diameter classes. The delay in recruitment from smaller size groups is directly associated with the delay in establishment of reproduction, as shown in table 4.

SUMMARY

On the basis of data collected over a 9-year period from a series of 0.4-acre plots located in loblolly pine pulpwood stands of Virginia and the Carolinas, heavy thinning from below has produced greater returns during the decade after cutting than has moderate thinning from below, cutting to 4 or 12 seed trees, shelterwood, or cutting to a 7.0-inch diameter limit. The shelterwood cutting showed the next best return, followed by moderate thinning from below, 12 seed trees, four seed trees, and diameter limit. Regeneration cuttings (seed tree and shelterwood) in these 25- to 30-year-old stands have failed to reproduce an adequate stand of pine within a reasonable time. Recent research findings pertaining to preharvest seed-tree release, seedbed preparation, and hardwood control offer a means by which this problem may be overcome under intensive management. Cutting to a 7.0-inch minimum diameter limit is the least favorable of all methods tested, because of a relatively high mortality and low growth rate.

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